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A MODEL OF THE RELATIVE CONTRIBUTION OF ATMOSPHERIC LEAD TO TOTAL HUMAN LEAD EXPOSURE IN THE UNITED STATES

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16. ABSTRACT

This paper describes a systematic evaluation of the total lead exposure of humans from both natural and anthropogenic sources. The evaluation is a multi-media approach that establishes an intermediate step in modelling the relationship between air lead and tissue lead. The model summarizes the total human exposure to lead from all sources in anticipation that such information can be correctly applied to physiological models that interpret the relationship between lead exposure and tissue lead concentrations. Only those pathways that expose the human body to lead in the human environment are discussed. The model does not attempt to define exposure in natural ecosystems nor is it concerned with details of the physiological processes affecting the distribution of lead within the human body.

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INTRODUCTION

This paper describes a systematic evaluation of the total lead exposure of humans from both natural and anthropogenic sources. The evaluation is a multi-media approach that establishes an intermediate step in modelling the relationship between air lead and tissue lead. The model summarizes the total human exposure to lead from all sources in anticipation that such information can be correctly applied to physiological models that interpret the relationship between lead exposure and tissue lead concentrations. Only those pathways that expose the human body to lead in the human environment are discussed. The model does not attempt to define exposure in natural ecosystems nor is it concerned with details of the physiological processes affecting the distribution of lead within the human body.

The model distinguishes between natural and anthropogenic lead and attempts to identify anthropogenic lead by source. If a regulatory decision must be based on the relationship between ambient air lead and human health, it is imperative that decisionmakers have the best description of the magnitude of total anthropogenic lead exposure for humans. With a multimedia exposure model, this decision can be based on that fraction of the total exposure that is derived from the atmosphere, from canned food, or from other sources more difficult to characterize.

THE APPROACH

For the purposes of this discussion, exposure is defined as the total amount of lead that enters the human body by inhalation or oral consumption. Figure 1 shows the conceptual model of the multimedia approach, identifying four compartments or reservoirs that contribute to the human exposure to lead: air, food, water and dust. Within each reservoir there is a complex mixture of lead from several sources: atmospheric lead in air, food and dust; metallic lead (solder) in food and water; and pigment lead in dust. All of these are in addition to natural lead found in each reservoir. Figure 2 describes the sources of lead and the network of pathways that lead to the four reservoirs of human exposure.

Categories of Lead Exposure.

Only a small fraction of the total lead exposure involves inhalation. Much larger amounts of anthropogenic lead are consumed inadvertantly in dust and food contaminated with particulate matter. Lead particles enter the food cycle by wet or dry deposition during growth, harvesting, and transportation of crops, and the processing and preparation of food. Similar processes add anthropogenic lead, either atmospheric or otherwise, to dust.

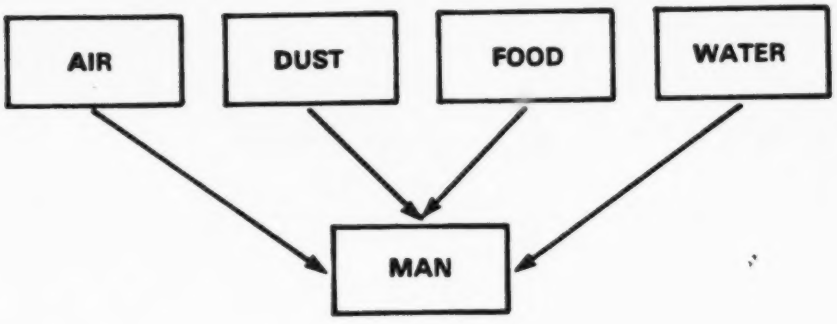

FIGURE 1. A simple model of human lead exposure that does not distinguish among sources of anthropogenic lead.

Sources of Lead.

Natural lead occurs in crustal rocks which are weathered to form soils. This lead is transferred to soil moisture in very small amounts and is taken up by plant roots, including agricultural crops. A portion of the lead in soil is also of atmospheric origin, and some urban soils contain large amounts of pigment lead.

Atmospheric lead originates with emissions from mobile and stationary sources. A large fraction (70-90%) of this lead comes from lead additives in gasoline. In the atmosphere, the lead can be found on particulate matter over a wide size range, although particles smaller than one micrometer contain proportionately higher concentrations of lead. Nearly all of the particulate matter inhaled and much of the particulate matter added to food, beverages, and dusts is of atmospheric origin.

Exposure to metallic lead occurs primarily by the consumption of food in cans with a lead soldered seam and of water distributed either in lead pipes or in copper pipes sealed with lead solder at the joints.

Normal exposure to pigment lead occurs by the consumption of dust from houses with interior lead paint, or from soil dusts near structures painted with lead based paint. The consumption of paint chips and the inhalation or consumption of dust from paint removal projects are special cases that are discussed later.

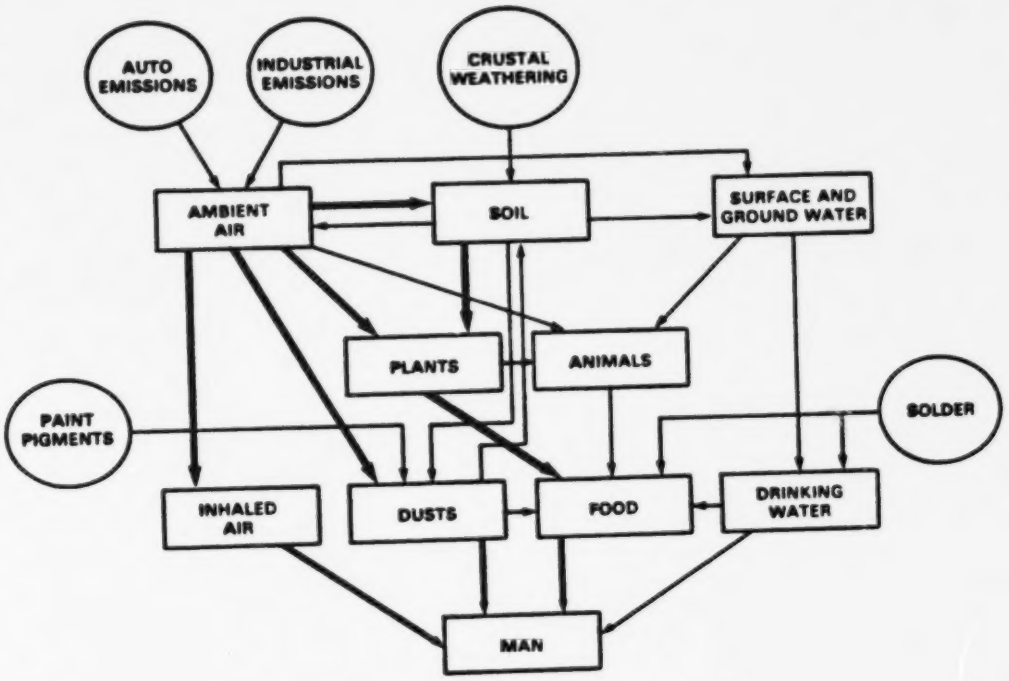

FIGURE 2. Exposure of humans to lead from all major sources along the most common environmental pathways. The heavy arrows represent the primary routes of exposure to atmospheric lead.

Baseline Exposure.

Because it is difficult to define in detail that portion of human lead exposure that can be attributed to natural lead alone, it is more productive to assume some fundamental level of exposure that includes a relatively small amount of natural lead and a consistent anthropogenic lead component. This fundamental level is referred to as the baseline level, beyond which any additional exposure would be a matter of choice, habit, or circumstance. At the baseline level, the model for human exposure to lead assumes the individual lives in a non-urban community not proximate to stationary or mobile sources of lead, in a house without lead-based paints, eats a typical diet, and engages in no lead-related occupational or avocational activities. The baseline level is not the natural level of lead exposure comparable to what one would expect of prehistoric man, but the presumed lowest level of exposure under normal living conditions. It would be virtually impossible for this person to reduce his level of exposure without extraordinary changes in lifestyle.

THE MODEL

The data that are input to the model are the concentrations of lead in the various components, the amounts of each item in the compartment consumed, and the relative fractions of each component that can be attributed to atmospheric and metallic lead. If there is uncertainty concerning the source, the minimum fraction is used, and any exposure beyond the minimum level is attributed to lead of "undetermined origin." The model runs on a microcomputer with a custom template adapted to a standard spreadsheet format. Repeated reanalysis of human exposure with the model are possible using any reasonable values to demonstrate increased exposure due to departures from the baseline situation.

Exposure to Lead.

$$L_t = L_f + L_a + L_d \qquad (1)$$

The total lead exposure (L_t) is the sum of food and beverage exposure (L_f), air exposure (L_a), and dust exposure (L_d). These components of Equation 1 correspond to the four compartments of Figure 1, except that food and water are combined for the convenience of the existing database. This database consists of a food consumption study by Pennington (1983), and a corresponding FDA Market Basket Survey (US FDA, 1985). Pennington (1983) reported a study of food consumption by eight age/sex groups: infants aged 6-18 months, toddlers aged 2 years, male and female teenagers aged 14-16, male and female young adults aged 25-30, and male and female seniors aged 60-65. The study identified and measured consumption in 231 food categories. These are the same food categories used by the FDA Market Basket survey. Lead concentration data for 30 categories of baby food are not available, so the first age category is not included in this report.

In each food category, the daily exposure to lead by source is a product of the amount of food consumed in each category and the concentration of lead in that category.

$$L_f = F_1C_1 + F_2C_2 + \ldots . F_nC_n \qquad (2)$$

L_f = total amount of lead consumed in food and beverages (ug/day)

F_i = amount of food in category (i) consumed (g/day)

C_i = concentration of lead in food category (i) (ug/g)

n = number of food categories (201)

Adjusting for the time spent indoors and outdoors, the exposure due to inhalation is calculated according to Equation 3:

$$L_a = A_i C_i + A_o C_o \quad (3)$$

L_a = total amount of lead inhaled in air (ug/day)
A_i, A_o = volume of air inhaled while indoors or outdoors (m^3/day)
C_i, C_o = concentration of lead in indoor or outdoor air (ug/m^3)

Lead exposure to dust (Figure 3) is estimated as the amount of dust consumed times the baseline concentration of lead in dust (Equation 4). Many recent publications that analyze human lead exposure cite a single reference by Day et al. (1975), which concluded that children consume 100 mg of dust per day. In the absence of a better published value and because it appears to be a very conservative estimate of dust consumption, the same value is used in this model also. But it should be noted with caution that much of the sensitivity of the model relies heavily on this assumption. For adults, a value of 20 mg dust is used as the assumed daily dust consumption.

$$L_d = D_f(C_h P_h + C_s P_s + C_o P_o) \quad (4)$$

L_d = total amount of lead consumed in dust (ug/day)

C_h, C_s, C_o = concentrations of lead in household, street/playground, and secondary occupational dust (ug/g)

P_h, P_s, P_o = fraction of consumed dust attributable to household, street/playground, and secondary occupational dust

D_f = total amount of dust consumed from all sources (g/day)

To identify the contribution of lead by source within each category, it is necessary to modify Equations 2 and 4 by inserting a source coefficient (R_{xn}) for each expression. Equations 5 and 6 are expansions of Equations 2 and 4 to account for the source of the lead. Equation 3 was not modified because it is assumed that all inhaled lead is of atmospheric origin. This assumption is valid for the baseline situation and most special circumstances except some that involve occupational exposure.

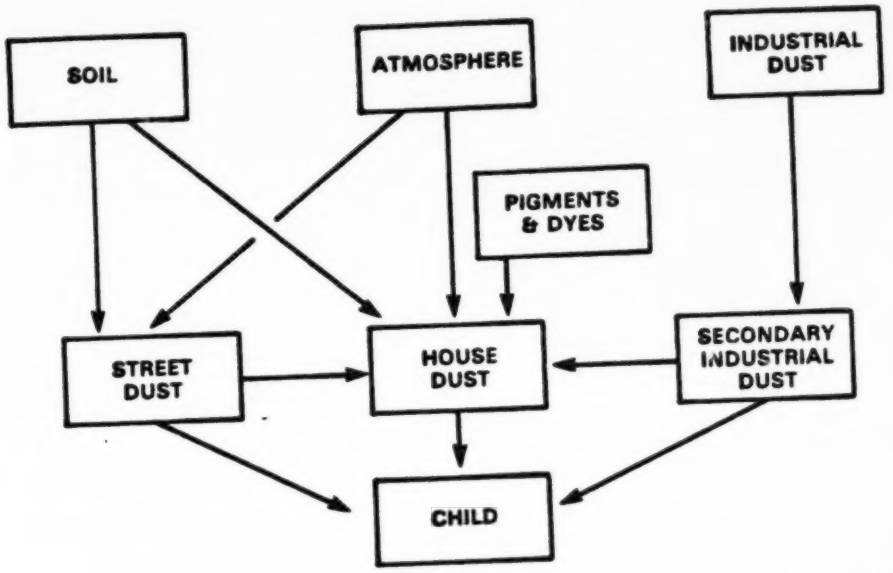

FIGURE 3. A simple model of the sources and pathways of lead in dust. This model demonstrates the three major types of dust in the environment of children, and the complexity of the sources for each type of dust.

CROP	NATURAL LEAD	INDIRECT ATMOSPHERIC LEAD	DIRECT ATMOSPHERIC LEAD	TOTAL LEAD
Wheat	0.0015	0.0015	0.0340	0.0370
Potatoes	0.0045	0.0045	0.0000	0.0090
Field corn	0.0015	0.0015	0.0190	0.0220
Sweet corn	0.0015	0.0015	0.0000	0.0030
Soybeans	0.0210	0.0210	0.0000	0.0420
Peanuts	0.0050	0.0050	0.0000	0.0100
Onions	0.0025	0.0025	0.0000	0.0050
Rice	0.0015	0.0015	0.0040	0.0070
Carrots	0.0045	0.0045	0.0000	0.0090
Tomatoes	0.0010	0.0010	0.0000	0.0020
Spinach	0.0015	0.0015	0.0420	0.0450
Lettuce	0.0015	0.0015	0.0100	0.0130
Beef (muscle)	0.0002	0.0002	0.0200	0.0204 *
Pork (muscle)	0.0002	0.0002	0.0600	0.0604 *

*Data from Penumarthy et al. (1980)

TABLE 1. Background concentrations of lead in basic food crops and meats. Except as indicated, data are from Wolnik et al. (1983, 1985). Units are in ug/g fresh weight.

	6-11 mo ug/day	2 yr ug/day	14-16 F ug/day	14-16 M ug/day	25-30 F ug/day	25-30 M ug/day	60-65 F ug/day	60-65 M ug/day	AVG FOR AGE GPS ug/day
TOTAL PB CONSUMPTION	13.7	25.1	31.5	45.0	32.1	45.3	32.3	39.8	33.1
PB FROM ATMOSPHERIC SOURCES	4.8	9.4	12.9	18.7	12.9	19.0	12.2	15.6	13.2
PB FROM METALLIC SOURCES	7.3	11.5	12.8	18.8	13.0	18.0	13.8	17.0	14.0
NATURAL PB CONSUMPTION	0.5	1.4	2.0	2.5	2.1	2.8	2.2	2.5	2.0
PB FROM INDIRECT ATMOSPHERIC SOURCES	0.5	1.4	2.0	2.5	2.1	2.8	2.2	2.5	2.0
PB FROM UNDETERMINED SOURCES	0.6	1.4	1.9	2.6	1.9	2.5	1.9	2.3	1.9
% OF TOTAL PB FROM ATMOS SOURCES	34.6%	37.5%	41.1%	41.5%	40.2%	42.0%	37.8%	39.1%	39.8%
% OF TOTAL PB FROM METALLIC SOURCES	53.3%	45.8%	40.5%	41.7%	40.7%	39.8%	42.8%	42.7%	42.4%
% OF TOTAL PB FROM NATURAL SOURCES	3.9%	5.5%	6.2%	5.5%	6.6%	6.3%	6.8%	6.2%	6.0%
% OF TOTAL PB FROM INDIRECT ATM SOURCES	3.9%	5.5%	6.2%	5.5%	6.6%	6.3%	6.8%	6.2%	6.0%
% OF TOTAL PB FROM UNDETERMINED SOURCES	4.3%	5.6%	5.9%	5.7%	6.0%	5.6%	6.0%	5.8%	5.7%

TABLE 2. Lead consumed in food and beverages by seven age/sex groups. A total of 201 food categories were individually evaluated for lead contributions from the atmosphere, metallic solder, natural lead, and atmospheric lead in soil (indirect atm). Lead that could not be placed in one of these groups was classified as lead of undetermined origin.

LEAD CONSUMED IN DUST	DUST LEAD ug/g	DUST INGESTED g/day	LEAD CONSUMED ug/day
CHILDREN			
household dusts	300	0.05	15.0
street dusts	90	0.04	3.6
occupational dusts	150	0.01	1.5
TOTAL		0.10	20.1
ADULTS			
household dusts	300	0.01	3.0
street dusts	90	0.00	0.0
occupational dusts	150	0.01	1.5
TOTAL		0.02	4.5

TABLE 3. Dust consumed by children and adults. The three types of dust each have different compositions, and are consumed in different amounts. The total amount of dust consumed by children is arbitrarily distributed in the amounts indicated in column two.

The food crop data (Table 1), taken at maturity prior to harvest, showed that leafy crops contained more lead than root crops, which were higher in lead than fruits. The root crops in this study are storage organs of photosynthetic products translocated from the leaves. (The fibrous roots that absorb nutrients from the soil are normally higher in lead content than shoots, leaves, or fruits, but were not a part of this study). On the assumption that there is some atmospheric lead in all vegetation, the assignment of a source coefficient to Equation 2 is a two step process. First, the amount of atmospheric lead in the harvested crop is estimated based on the crop type (leafy vegetable, root vegetable, grain, or fruit). Then the amount of lead added during transportation, processing, and packaging is determined based on the difference between the FDA Market Basket Survey and the food crop data, and the atmospheric and metallic fractions are estimated. Figure 4 depicts the conceptual model of lead added during the transformation from crops in the field to food on the table. In those cases where packaging occurred without further processing, very little additional lead can be detected. In other cases, additional lead seems to appear in proportion to the approximate time required for processing. The process is similar for meats.

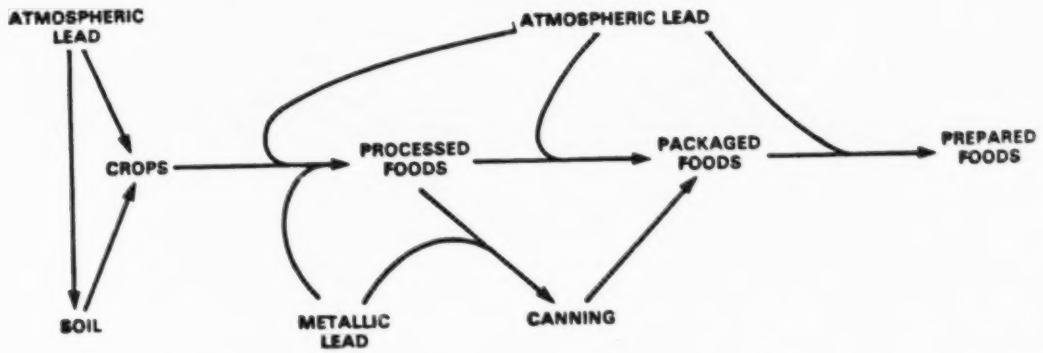

FIGURE 4. Potential contributions of atmospheric lead to food crops during growth, harvesting, processing, and preparation.

In the several cases where canned fruits and vegetables were analyzed separately from their fresh or frozen counterparts, lead in the canned food averaged 0.15 ug/g higher than uncanned. Between these two sources of anthropogenic lead, nearly all of the added lead could be accounted for, with only a small fraction attributed to lead of undetermined origin (Table 2). The result is a separate source coefficient for the atmospheric, metallic, natural, and undertermined lead for each food and beverage category (Equation 5). For added exposure above the baseline situation, there is a source coefficient for pigment lead where paint chips or dust are incorporated into the food preparation process.

$$L_f = F_1 C_1 R_{a1} + F_1 C_1 R_{m1} + F_1 C_1 R_{s1} + F_1 C_1 R_{u1} + F_2 C_2 R_{a2} + \ldots F_n C_n R_{un} \quad (5)$$

R_{an}, R_{mn}, R_{sn}, R_{un} = source coefficients for atmospheric, metallic, and soil lead and for lead of undetermined origin for (n) food categories. Soil lead includes natural and indirect atmospheric lead.

There are three general types of dust: street dust, household dust, and secondary occupational dust (Figure 3). Street dust in the baseline situation includes playground dust and is assumed to contain lead from the soil and the atmosphere . There does not yet appear to be a linear or curvilinear relationship between air lead and dust lead concentrations. Therefore, data are substituted empirically into the model from published values of lead in dust where air lead concentrations have been measured. In non-baseline situations, street dust also contains pigment lead from exterior house paint and lead from nearby industrial activities, but this lead is conceptually excluded by the definition of the baseline situation. On the other hand, household dust is a mixture of soil lead (natural and indirect atmospheric) and direct atmospheric lead, but includes a component of pigments and dyes from a variety of other sources that must be considered an integral part of the typical home. Secondary occupational dust in the baseline situation contains soil and anthropogenic lead in a composition that varies with each home environment. Consequently, most of the lead in occupational dust is of undetermined origin.

$$L_d = D_t [C_h P_h R_{ah} + C_h P_h R_{sh} + C_h P_h R_{uh} + C_s P_s R_{as} + \ldots C_o P_o R_{uo}] \quad (6)$$

$R_{ah} .. R_{uo}$ = source coefficients for lead in household, street, or occupational dust representing the contribution of atmospheric and soil lead, and lead of undetermined origin.

RESULTS

Baseline Exposure.

Food and beverage exposure may be found on Table 2 and the daily exposure to lead in dust is given on Table 3 for children and adults.

The total exposure, a summation of inhaled lead, food and beverage lead, and dust lead, is shown on Table 4. The baseline parameters discussed above suggest that approximately 60% of the lead consumed daily by children in a baseline situation is of atmospheric origin. The atmospheric fraction is higher for children because of the presumed amount of dust consumed. Much of the remaining lead comes from the solder in food cans. About 6% is of natural origin, and 3 to 4% is of undetermined origin. In the baseline situation it is likely that most of the lead of undetermined origin is either atmospheric or metallic lead.

EXPOSURE	2 yr	14-16 F	14-16 M	25-30 F	25-30 M	60-65 F	60-65 M
	ug/day	ug/day	ug/day	ug/day	ug/day	ug/day	ug/day
AIR	0.5	1.0	1.0	1.0	1.0	1.0	1.0
FOOD AND BEVERAGES							
Atm	9.4	12.9	18.7	12.9	19.0	12.2	15.6
Met	11.5	12.8	18.8	13.0	18.0	13.8	17.0
Nat	1.4	2.0	2.5	2.1	2.8	2.2	2.5
Indirect Atm	1.4	2.0	2.5	2.1	2.8	2.2	2.5
Undetermined	1.4	1.9	2.6	1.9	2.5	1.9	2.3
Total food and beverages	25.1	31.5	45.0	32.1	45.3	32.3	39.8
DUST							
Atm	17.9	4.1	4.1	4.1	4.1	4.1	4.1
Met	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nat	1.5	0.3	0.3	0.3	0.3	0.3	0.3
Indirect Atm	0.5	0.1	0.1	0.1	0.1	0.1	0.1
Undetermined	0.2	.0	.0	.0	.0	.0	.0
Total dust	20.1	4.5	4.5	4.5	4.5	4.5	4.5
TOTAL EXPOSURE							
Atm	27.8	18.0	23.7	17.9	24.1	17.2	20.6
Met	11.5	12.8	18.8	13.0	18.0	13.8	17.0
Nat	2.9	2.3	2.8	2.4	3.1	2.5	2.8
Indirect Atm	1.9	2.1	2.6	2.2	2.9	2.3	2.6
Undetermined	1.6	1.9	2.6	2.0	2.6	2.0	2.3
Total Air, Food and Dust	45.7	37.0	50.5	37.6	50.8	37.8	45.3
% Atmospheric	60.9%	48.7%	47.0%	47.8%	47.4%	45.6%	45.5%
% Metallic	25.1%	34.5%	37.2%	34.7%	35.5%	36.5%	37.5%
% Natural	6.3%	6.1%	5.5%	6.4%	6.2%	6.6%	6.1%
% Indirect Atmospheric	4.1%	5.6%	5.1%	5.9%	5.8%	6.0%	5.7%
% Undetermined	3.5%	5.1%	5.2%	5.2%	5.1%	5.2%	5.2%
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

TABLE 4. A summary of the total baseline exposure of humans to lead by source and age/sex group.

In the baseline form, this model focuses clearly on the sources of lead that comprise the greatest exposure to humans. Because the baseline parameters are carefully selected to exclude additional lead exposure, the model demonstrates the lowest achievable lead exposure in the United States without unreasonable changes in lifestyle.

The model does not establish baseline parameters. The baseline parameters were inserted into the model from the available literature and can be changed if the conditions or assumptions change. This flexibility allows the potential for predicting lead exposure under expected conditions in the future or exposure in countries with food consumption habits similar to Americans. The model is also not limited to lead exposure. If the required data are available, they may be inserted in the same manner as the lead data, assuming there are no other routes of exposure, such as dermal absorption.

Additional Exposure.

In order to predict exposure beyond the baseline level, it is necessary to estimate the change in parameters for the "above baseline" situation. For example. an urban child would breathe the same amount of air and consume the same amount of dust as a nonurban child, but with a higher concentration of lead (e.g. 1.5 ug/m^3 vs 0.1 ug/m^3 for air and 1000 ug/g vs 300 ug/g for dust) in each case. Food consumption would probably remain the same, although the argument could be made that kitchen preparation in an urban situation may add more lead than in a rural location. Inserting these changes in the model for baseline exposure gives the new exposure (Table 5). If the family also lives in a house with lead-based paint, the household dust level might increase to 2000 ug/g, giving a total exposure profile as indicated in Table 6.

EXPOSURE	2 yr	14-16 F	14-16 M	25-30 F	25-30 M	60-65 F	60-65 M
	ug/day	ug/day	ug/day	ug/day	ug/day	ug/day	ug/day
AIR	7.5	15.0	15.0	15.0	15.0	15.0	15.0
FOOD AND BEVERAGES							
Atm	9.4	12.9	18.7	12.9	19.0	12.2	15.6
Met	11.5	12.8	18.8	13.0	18.0	13.8	17.0
Nat	1.4	2.0	2.5	2.1	2.8	2.2	2.5
Indirect Atm	1.4	2.0	2.5	2.1	2.8	2.2	2.5
Undetermined	1.4	1.9	2.6	1.9	2.5	1.9	2.3
Total food and beverages	25.1	31.5	45.0	32.1	45.3	32.3	39.8
DUST							
Atm	108.4	11.0	11.0	11.0	11.0	11.0	11.0
Met	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nat	1.5	0.3	0.3	0.3	0.3	0.3	0.3
Indirect Atm	0.5	0.1	0.1	0.1	0.1	0.1	0.1
Undetermined	1.1	0.1	0.1	0.1	0.1	0.1	0.1
Total dust	111.5	11.5	11.5	11.5	11.5	11.5	11.5
TOTAL EXPOSURE							
Atm	125.3	38.9	44.7	38.9	45.0	38.2	41.6
Met	11.5	12.8	18.8	13.0	18.0	13.8	17.0
Nat	2.9	2.3	2.8	2.4	3.1	2.5	2.8
Indirect Atm	1.9	2.1	2.6	2.2	2.9	2.3	2.6
Undetermined	2.5	2.0	2.7	2.0	2.7	2.0	2.4
Total Air, Food and Dust	144.1	58.0	71.5	58.6	71.8	58.8	66.3
% Atmospheric	87.0%	67.2%	62.4%	66.4%	62.7%	64.9%	62.7%
% Metallic	8.0%	22.0%	26.3%	22.3%	25.1%	23.5%	25.6%
% Natural	2.0%	3.9%	3.9%	4.1%	4.4%	4.2%	4.2%
% Indirect Atmospheric	1.3%	3.6%	3.6%	3.8%	4.1%	3.9%	3.9%
% Undetermined	1.7%	3.4%	3.8%	3.5%	3.7%	3.5%	3.6%
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

TABLE 5. A summary of total exposure for an urban family not living near a point source of lead. In the departure from the baseline situation, the air lead concentration has been changed from 0.1 ug/m^3 to 1.5 ug/m^3, the household dust from 300 to 1000 ug/g, and the street dust from 90 to 1500 ug/g.

EXPOSURE	2 yr ug/day	14-16 F ug/day	14-16 M ug/day	25-30 F ug/day	25-30 M ug/day	60-65 F ug/day	60-65 M ug/day
AIR	7.5	15.0	15.0	15.0	15.0	15.0	15.0
FOOD AND BEVERAGES							
Atm	9.4	12.9	18.7	12.9	19.0	12.2	15.6
Met	11.5	12.8	18.8	13.0	18.0	13.8	17.0
Nat	1.4	2.0	2.5	2.1	2.8	2.2	2.5
Indirect Atm	1.4	2.0	2.5	2.1	2.8	2.2	2.5
Undetermined	1.4	1.9	2.6	1.9	2.5	1.9	2.3
Total food and beverages	25.1	31.5	45.0	32.1	45.3	32.3	39.8
DUST							
Atm	103.9	10.1	10.1	10.1	10.1	10.1	10.1
Met	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nat	1.5	0.3	0.3	0.3	0.3	0.3	0.3
Indirect Atm	0.5	0.1	0.1	0.1	0.1	0.1	0.1
Undetermined	55.6	11.0	11.0	11.0	11.0	11.0	11.0
Total dust	161.5	21.5	21.5	21.5	21.5	21.5	21.5
TOTAL EXPOSURE							
Atm	120.8	38.0	43.8	38.0	44.1	37.3	40.7
Met	11.5	12.8	18.8	13.0	18.0	13.8	17.0
Nat	2.9	2.3	2.8	2.4	3.1	2.5	2.8
Indirect Atm	1.9	2.1	2.6	2.2	2.9	2.3	2.6
Undetermined	57.0	12.9	13.6	12.9	13.6	12.9	13.3
Total Air, Food and Dust	194.1	68.0	81.5	68.6	81.8	68.8	76.3
% Atmospheric	62.2%	55.9%	53.7%	55.4%	54.0%	54.2%	53.3%
% Metallic	5.9%	18.8%	23.0%	19.0%	22.0%	20.1%	22.3%
% Natural	1.5%	3.3%	3.4%	3.5%	3.8%	3.6%	3.6%
% Indirect Atmospheric	1.0%	3.0%	3.2%	3.2%	3.6%	3.3%	3.4%
% Undetermined	29.4%	18.9%	16.7%	18.9%	16.6%	18.8%	17.4%
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

TABLE 6. Total lead exposure for an urban family living in housing with lead-based paint. In addition to the urban family changes made for Table 5, the household dust has been changed to 2000 ug/g. This dust is pigment lead, which shows up as lead of undetermined origin because there is no special category for pigment lead.

SUMMARY

This model uses a flexible structure that is amenable to changes in either the baseline information or formula for calculation. The output is informative from the standpoint of presenting timely summaries of changes in exposure with any departure from the baseline situation, and changes to the baseline exposure expected from any modification of ambient air quality.

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